

LASER RANGE POLE  
FIELD EVALUATION REPORT

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PREPARED FOR: NASA GODDARD SPACE FLIGHT CONTROL  
AND  
UNITED STATES FOREST SERVICE

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## FIELD EVALUATION REPORT (LASER RANGE POLE)

### 1.0 INTRODUCTION

A field evaluation of the Laser Range Pole equipment was conducted by the Forest Service during the month of October 1973. The basic plan for field evaluation was to expose the equipment to the actual people and environment for which it was intended and determine through the use of the equipment its resultant effectivity in terms of improved performance.

Important goals were as follows:

- a. Determine a "feel" for overall reliability and identify any weaknesses in design.
- b. Determine the effect of a thin, clean air environment on equipment performance.
- c. Identify human factors improvements.
- d. Identify areas in need of design improvement.
- e. Familiarize Region Cadastral Engineers with the operation of the equipment.
- f. Demonstrate it to other interested departments such as the Bureau of Land Management, Highway Department, Power Companies, etc.

The Forest Service representative responsible for the field evaluation was Bernie Hostrop, Cadastral Surveyor assigned to this program out of Washington D.C. Assisting him in Colorado were Tom Patterson and Tom Hensley. Hensley is a communications engineer from the Berkeley California Engineering Department of the Forest Service assigned to this program for the purpose of becoming proficient in the technical aspects of the equipment. Patterson is a high grade electronics technician assigned to assist Bernie in the demonstration and normal operation of the equipment. Joseph Rivera substituted for Tom Patterson in this capacity at the Tennessee and Florida field sites.

To assist in obtaining these goals an RCA representative, knowledgeable in the equipment design, was assigned to work with the Forest Service group during the Field Evaluation. The RCA representative was Earl Corey at the Colorado and Florida sites and Robert Guyer at the Tennessee site.

## 2.0 FIELD OPERATIONS

### 2.1 Colorado Field Site

Field Site: Roosevelt National Forest, Colorado

Dates: September 30 - October 13, 1973

Forest Service Personnel: Bernie Hostrop  
Tom Patterson  
Tom Hensley

RCA Personnel: Earl Corey

The first field site location was in the mountains about 50 miles northwest of Denver Colorado. As a home base during the two weeks we used the Foothills Ramada Inn just west of Denver. It was convenient to the regional F.S. office in Denver where some of the demonstrations were given. After demonstrating and testing the equipment near the regional office, plans were made with the Region Cadastral Engineer, Clyde Duren, to both evaluate and use the equipment for work in the local national forest. There was some thought given to bringing the equipment to the Black Hills in S. Dakota for boundary line work but it was decided that there was enough to do locally.

During the first week, day and night tests were made on ranges with known separation distances as well as tests at altitudes between 8 and 12 thousand feet. Two days were spent doing work for the crew in that area. They were very impressed with the equipment and the "work saving" it accomplished. When the

lines were run out using the headings determined by the equipment the crew was amazed at the accuracy. (Approx. 2" off true on half mile ranges.)

Some complications in the schedule arose as a result of our having to allot time to prepare for a news conference. Although the news conference was cancelled we did spend time making a movie depicting the use of the equipment on an actual site in the mountains.

The second week was spent alternately doing boundary line work in the mountains and writing material to be used for a news release in Washington. On Friday of this week a group of BLM (Bureau of Land Management) people were invited to witness a demonstration of the equipment. The demonstration went off very well and the group was favorably impressed. During the following week after I had left the site, the Forest Service representatives assisted the BLM people by using the equipment to obtain the heading on one of their more difficult one mile lines. We have since heard that the line was run and the deviation from true was less than two inches.

#### SUMMARY

The equipment performed better than expected in the high elevation clean air. No repairs or adjustments were necessary. All who witnessed its operation were greatly impressed with its usefulness.

## 2.2 Tennessee Field Site

Field Site: Cherokee National Forest, Tennessee

Dates: October 22 - October 26, 1973

F.S. Personnel: Bernie Hostrop  
Tom Hensley  
Joe Rivera

RCA Personnel: Robert Guyer

Walter Robillard the Chief Cadastral Engineer for the Southern Region coordinated the field work with the local surveying team of Carroll Pierce, Leroy Perkins and Jerry Wilson.

The Tennessee operation tested the use of the LRP in low elevation (1800 feet), hazy atmosphere, rugged thickly wooded terrain. Most of the boundary lines in this region are half mile or less in length, but one of those we worked on was 1.2 miles long.

All the survey boundaries were between FS and private land in different terrain. The local team had done an excellent preliminary investigation to determine the suitability of each corner for Laser Range Pole use.

The system completed all the recommended boundaries in less time than was allocated so we spent the remaining time comparing nighttime operation to daytime operation on the same range and on a "hands on" training session for the local team. The system performed flawlessly throughout the week. Everyone who operated the equipment was elated with it and had suggestions for its application. While they like the time the system will save them, it is the added precision that impressed the local team because of the attendant confidence in their work by the Forest Service land abutters. They say it is very embarrassing to have to stake and restake a property line several times

with the land owner looking on.

#### SUMMARY

There were no repairs or adjustments necessary on the equipment and the week's test was highly successful. Criticism of the equipment was all constructive and fell in the following general categories:

- 1) To a man, all those present, thought Kern equipment difficult to set-up and use. This assessment was slightly unfair, I felt, because the Kern equipment was not being used as it was intended and because of their lack of familiarity with Kern equipment.
- 2) RCA's design approach on this system now seems conservative so the users would like to see the system made smaller, lighter and less expensive.
- 3) As the ultimate user, the surveyor would like a larger role in creating the specifications for the equipment.

#### 2.3 Florida Field Site

Field Site: Osceola National Forest, Florida

Dates: October 29 - November 2, 1973

F. S. Personnel: Bernie Hostrop  
Tom Hensley  
Tom Patterson

RCA Personnel: Earl Corey

The equipment again worked flawlessly throughout the week and the headings for six miles of difficult boundary lines were determined and staked. Unlike Tennessee and Colorado the Florida terrain was very flat. The trees were tall straight hard pines and presented about the same degree of canopy problems as Colorado. On one occasion low clouds coupled with a minimum receiver angle of 20° prevented our operation on a one mile range. We returned the following day and still had difficulty operating over the one mile range. The weather was

exceptionally clear and cloudless. We decided to return late in the afternoon and operate at dusk when the background was reduced. There was no problem in operating at dusk, in fact, we had much more signal strength than was required. It should also be noted that radio communication was marginal during the day on that range. The radio batteries were run down and we did not have replacements. In the evening when we returned radio communication was much better but we also had fresh batteries. The terrain was flat but heavily treed with tall pines.

Several visitors from the Highway Department and Power Companies witnessed the operation during the week. To all of them this method of accurately determining heading seemed immediately applicable to their type work.

Many people who have seen the range pole in operation ask if there is any way of determining range as well as heading. With the present system the only way known is to obtain two heading angles from two points which are accurately identified by angle and distance. This could be done with a fair degree of accuracy with the presently used 1 second theodolite and an accurate DME (Distance Measuring Equipment).

#### SUMMARY

The equipment again operated throughout the week without need for repair or adjustment. Unfortunately much time was spent trying to locate corner markers. This should normally be done in advance so that the equipment can be more efficiently used while it is available.

### 3.0 PERTINENT OBSERVATIONS

3.1 Equipment worked without need for component replacement or adjustment throughout the field evaluation period. This not only provided an optimistic feeling for system reliability but also made possible a more extensive operating schedule and more meaningful test results.

3.2 The equipment operation is not seriously degraded by high altitude clean air but daylight operation at a half-mile separation can only be achieved with a dark background such as trees at elevations above 10,000 feet.

3.3 Night operation will substantially increase range. The maximum range at night was not determined, however, the following observations were made.

- a) At 9000 feet elevation in Colorado, night operation allowed operation of the center indicator up to an elevation angle of  $35^\circ$  with 1.2 mile separation. Under daylight conditions only left and right indicators operated and then only with a dark background.
- b) In Florida under exceptionally clear daylight conditions with 1 mile range and blue sky background left and right indicators operated 25% of the time - insufficient for heading determination. A test of the same range and same clear condition that night yielded center indications with 2/3 of the receiver aperture blocked indicating at least a six or seven times increase in signal to noise.



NOTE: Center Indicator operates only if sufficient signal is present to operate both channels when the vertical reticle line is splitting the laser beam.

- 3.4 It is important to adjust the focus of the theodolite to infinity prior to using it as a laser receiver. It would be desirable to have the stop on the focus knob set at infinity in order to easily identify this position of the knob. Out of focus condition will result in a broader than normal center angle. Since the theodolite is used to sight the first stake after the laser heading has been determined it is very possible for the focus knob to be left in a short range focus position.
- 3.5 To help determine the presence of a canopy problem with the transmitter, a prism was used to simultaneously sight the exit aperture of the laser and the clearance overhead. This scheme or an equivalent should be made a part of the equipment.
- 3.6 A small compass should be included in the Transmitter back pack to be used as an aid in orienting the broad side of the transmitter toward the Receiver Theodolite.
- 3.7 The receiver should have a sun shade to keep sunlight out of the optics. In Tennessee we discovered that sun incident upon the receiver objective lens area produced some false alarms and reduced system sensitivity. By shading the lens, on one boundary we worked to within 20° of the

sun over a 1.2 mile range with good consistent readings. On another boundary we worked to within 5° of the sun over a 1862 foot range with similar results. The implication is that forward sun scatter is not as much a problem as veiling glare (system sensitivity reduction from solar incidence on the optics).

- 3.8 All agreed that the optical axis of the laser transmitter should be on line with the plumb line centering axis. In the present equipment it is offset by about an inch.
- 3.9 If the radio link gating feature is to be incorporated in future equipment, provisions must be made for a more field worthy cable connection to the radio.
- 3.10 Better provisions for cable storage should be provided in the backpack. Present arrangement requires too much bending and will shorten the life of the cable.
- 3.11 A "motorboating" sound from the radio transceiver was first thought to be due to externally generated interferences. The actual cause appears to be R.F. coupling from the antenna back into the radio through the attached cable. Extra shielding or preferably an RF filter should be added to prevent this phenomenon. Lowering the antenna solved the problem in the field. A more rugged radio connector should also be designed into future unit.
- 3.12 During night operations it was difficult to identify which indicator light was operating on the Receiver Thiodolite display panel since they are all the same color.

Better identification could be either different color lights or illuminated arrow heads pointing left or right with a different color center indicator lamp.

- 3.13 A small flare gun was tried at the transmitter location to aid the Receiver operator in locating the approximate azimuth heading. This did not prove too useful during daytime but could be useful at night under conditions where a low elevation receiver field of view is possible. The range of the flare gun used was only about 300 feet vertical.
- 3.14 Under extremely clear daylight conditions system operation is sometimes marginal with a mile separation. To enhance system operation the receiver location should be chosen such that the sun is, as much as possible, to the rear of the receiver. Also the higher elevation angle deep blue sky background is better than the lighter blue at low elevation angles. Always avoid aiming at bright sunlit clouds since they are, by far, the worst background condition.
- 3.15 The weight of the Receiver Theodolite backpack (49 lbs.) is difficult to carry up steep inclines. The Transmitter backpack is much lighter (34 lbs.). This should also be considered when deciding which of the two markers the receiver should be set up on.

The canopy cover is another important consideration. The transmitter needs only a small hole in the canopy directly above the marker whereas the receiver needs a minimum of a few degrees az and el at a reasonable elevation angle.

Note: Forest Service personnel who carried the Receiver equipment in Colorado did not complain about the weight of the equipment but those of use who did in Tennessee and Florida who are not in as good physical condition found it difficult.

- 3.16 The metal tripod used for the Laser Transmitter is very unstable when sunlight is on it. The level bubbles continue to move and adjustment is almost continuous. The more stable wooden tripod was desired by all the F.S. surveyors who used it.
- 3.17 The two watt B&H radio Transceiver worked better than expected under one mile separation and difficult terrain conditions, however, the F.S. feels they would gladly trade the light weight feature of this radio for additional power to insure good operation without the need for a repeater.
- 3.18 The receiver battery switch should be marked with ON-OFF positions.
- 3.19 A test was made to determine the actual verticality of the laser beam as referenced to the bubble vial levels. This was checked by obtaining an angular heading with the receiver at a 30° elevation angle and repeating the measurement after rotating the transmitter 180° and releveling. The difference in readings was 5 seconds which is only 1.5 inches in a mile.
- 3.20 It was found that the greatest source of potential error is in staking the heading. The further away the first stake is placed the lesser any small error in initial plumb line alignment is magnified.

### 3.20 (Continued)

Before using the LRP, the original corner markers should be center punched (if they are not already) to provide a good starting point for the survey crew which will follow to stake the boundary line. A small error here can be greatly magnified over a one mile line.

3.2.1 The backpack frames for both the receiver and transmitter had projections on top that tended to get caught in brush and tree branches. These projections should be eliminated on future models.

3.2.2 The transmitter telescope lens cap has too many threads engaging it to the instruments. Reduce the number.